

PHYSICAL CHARACTERISTICS OF BARTLESVILLE AND BURBANK SANDS IN NORTHEASTERN OKLAHOMA AND SOUTHEASTERN KANSAS¹

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ABSTRACT

The Bartlesville and Burbank sands, which occur in the Cherokee shale of the Pennsylvanian series, are composed of quartz grains loosely cemented with a mixture of magnesium, iron, and calcium carbonate, and locally by silica, dolomite, or calcite. The sand commonly contains new quartz growth. Aside from quartz the sand contains $\frac{1}{2}$ -2 per cent, commonly 1 per cent mica, traces of feldspars, zircon, chlorite, glauconite, hornblende, rutile, magnetite, pyrite, and epidote, 10-20 per cent detrital rock fragments (chert, shale, and schist), and a trace to 10 per cent of carbonaceous material. Locally, as much as 50 per cent of the sand grains are composed of altered magnetite. Marine fossils were found in the sands and also in thin limestone and shale beds within and immediately above and below the sands.

The sands in most localities are predominantly fine-grained, but locally have a large content of medium and coarse grains and a trace of very coarse grains. The sand in most localities contains 10 per cent silt and clay, but locally the fraction ranges from 5 to 40 per cent. Most of the medium-grained sand and essentially all the finer grains are angular to sub-angular; locally, one-third of the medium grains and, in all localities where present, most of the coarse and very coarse grains are sub-rounded to rounded.

The Bartlesville and Burbank sands are so similar in composition and physical characteristics that they can not be differentiated with certainty although certain differences can be distinguished in sands from two or more specific localities.

INTRODUCTION

More than a year has been spent in a microscopic study of the Bartlesville and Burbank sands in Osage and Kay counties, and a few localities east of Osage County, in Washington and Nowata counties, Oklahoma, and in Greenwood, Butler, and Cowley counties, Kansas (Fig. 1). Most of the work was done on the sands in Osage County. Cuttings from approximately 700 wells were examined. Cores from the sand in the Madison, Edwards Extension, and Quincy fields in Greenwood County, the Haverhill field in Butler County, and the Rainbow Bend field in Cowley County, Kansas, and the Burbank, South Burbank, Pershing, and Avant fields in Osage County, and Coodys Bluff, Delaware, Childers, and Alluwe fields in Nowata County, Oklahoma, were examined.

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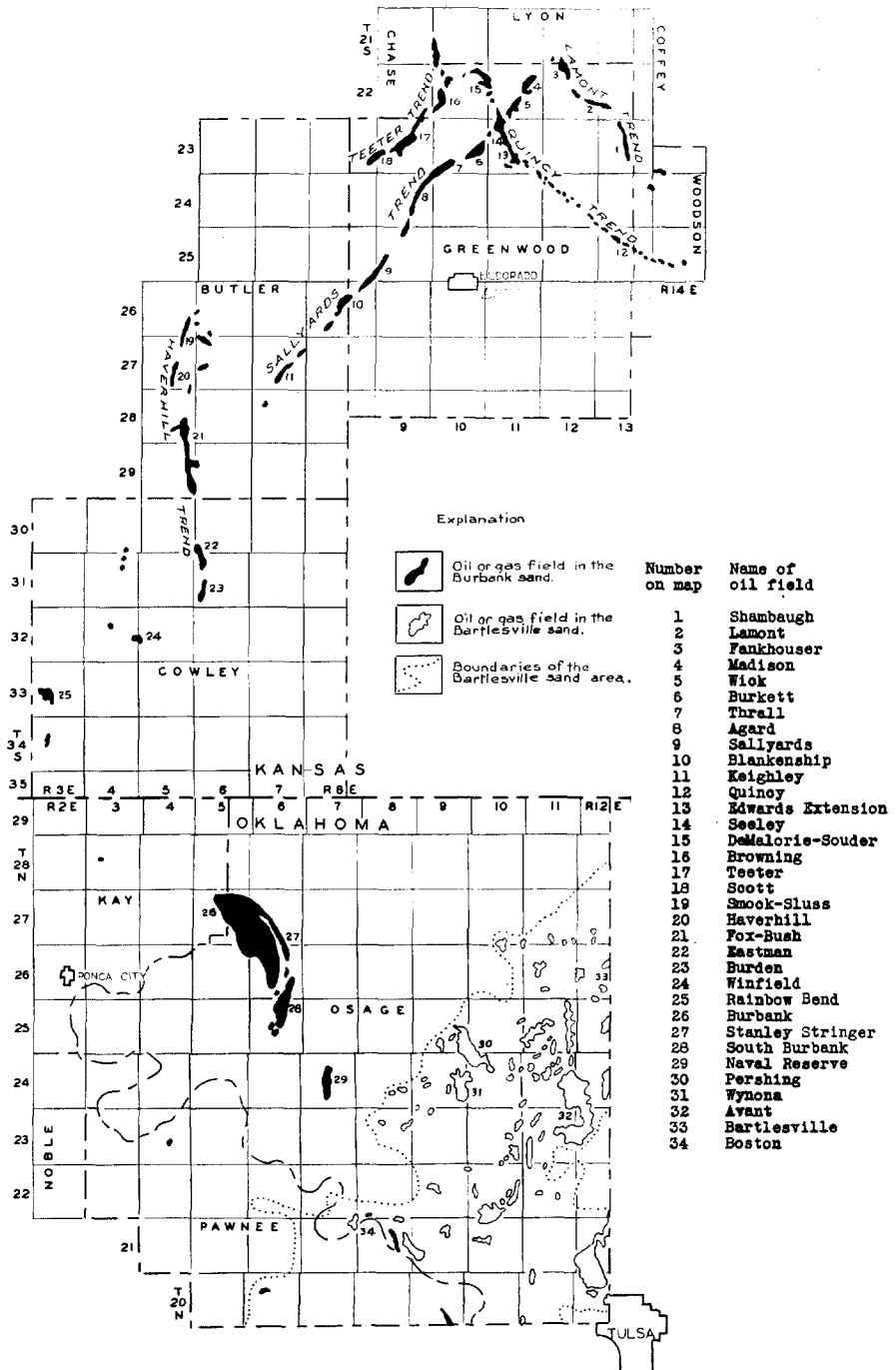


FIG. 1.—Map showing part of region in Oklahoma and Kansas, which contains Bartlesville and Burbank sands.

The study included the examination of outcrop samples from the Moberly, Warrensburg,³ and Aurora⁴ channel sandstones of Missouri, which have been described as sand-filled stream channels of Pennsylvanian age, and the Bluejacket sandstone in southeastern Kansas and northeastern Oklahoma, which is equivalent to a part of the Bartlesville sand.⁵

Samples of beach sands from the barrier beaches of Virginia and from the Pleistocene beaches in the vicinity of the Dismal Swamp of Virginia were examined microscopically and comparisons were made with samples of the channel sandstones of Missouri and well samples of the Bartlesville and Burbank sands in Kansas and Oklahoma. Approximately 150 thin sections of the sands were made from cores of producing wells and from outcrop samples. These were studied with a petrographic microscope.

The studies conducted by the members of the United States Geological Survey party with whom the writer collaborated indicate that the Bartlesville and Burbank sands were deposited as offshore bars, also called barrier beaches, on the western shore of the Cherokee sea which occupied much of northeastern Oklahoma and eastern Kansas. The microscopic study furnished important data that contributed to these conclusions. However, this paper describes only the characteristics of the sands; their origin is discussed in a separate paper by several members of the party.⁶

The combined work of the members of the United States Geological Survey party established to their satisfaction the facts that the Bartlesville sand is older and stratigraphically lower than the Burbank sand, that the Kansas shoestring sands of Greenwood, Butler, and Cowley counties are of approximately the same age as the Burbank, South Burbank, and Naval Reserve sands, and that the Red Fork sand of southern Osage County is approximately equivalent to the Burbank

³ Arthur Winslow, "The Higginsville Sheet," *Bull. Missouri Geol. Survey*, Vol. 9 (1896), pp. 45-54.

C. F. Marbut, "Geological Description of the Calhoun Sheet," *Missouri Geol. Survey*, Vol. 12, Pt. 2 (1898), pp. 158-59.

Henry Hinds and F. C. Greene, "The Stratigraphy of the Pennsylvanian Series in Missouri," *Missouri Bur. Geol. and Mines*, Vol. 13, 2d Ser. (1915), pp. 95-96.

⁴ E. M. Shepard, "Report on Green County, Missouri," *Missouri Geol. Survey*, Vol. 12 (1898), pp. 127-39.

R. B. Rutledge, "Geology of Lawrence County, Missouri," *Missouri Bur. Geol. and Mines*, unpublished manuscript.

⁵ L. C. Snider, *Petroleum and Natural Gas in Oklahoma*, Harlow-Ratliff Company, Oklahoma City, Oklahoma (1913), p. 46.

⁶ N. W. Bass, Constance Leatherock, W. R. Dillard, and L. E. Kennedy, "Origin and Distribution of the Bartlesville and Burbank Shoestring Oil Sands in Parts of Oklahoma and Kansas," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 21, No. 1 (January, 1937), pp. 30-66.

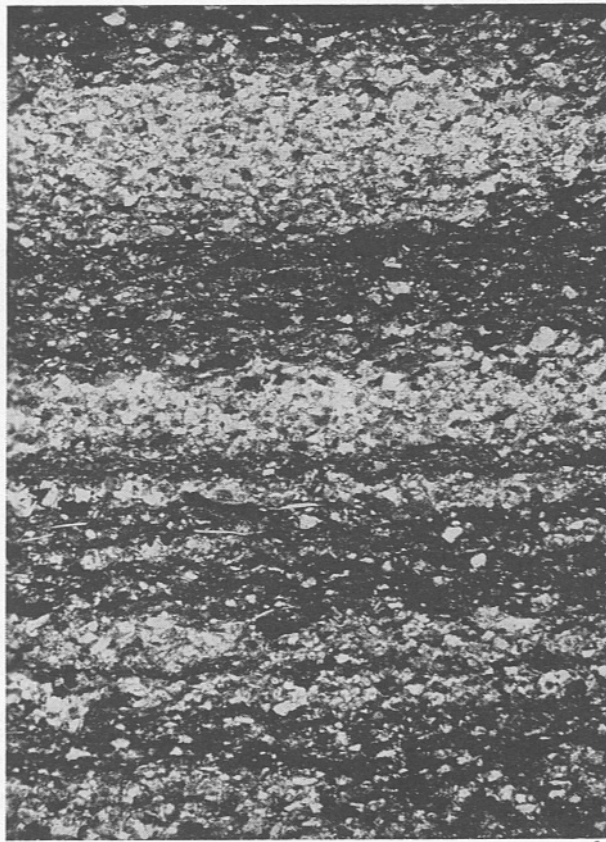


FIG. 2A.—Photomicrograph of thin section from core of Bartlesville sand taken from "break" in sand at depth of about 1,650 feet in W. C. McBride, Inc., well No. 52 in NE. $\frac{1}{4}$ of Sec. 18, T. 23 N., R. 12 E., Avant oil field, Oklahoma. Light bands are silt and black bands are silty carbonaceous shale. White lines $\frac{1}{4}$ inch or less long are mica flakes. (Magnified 25 times; crossed nicols.)

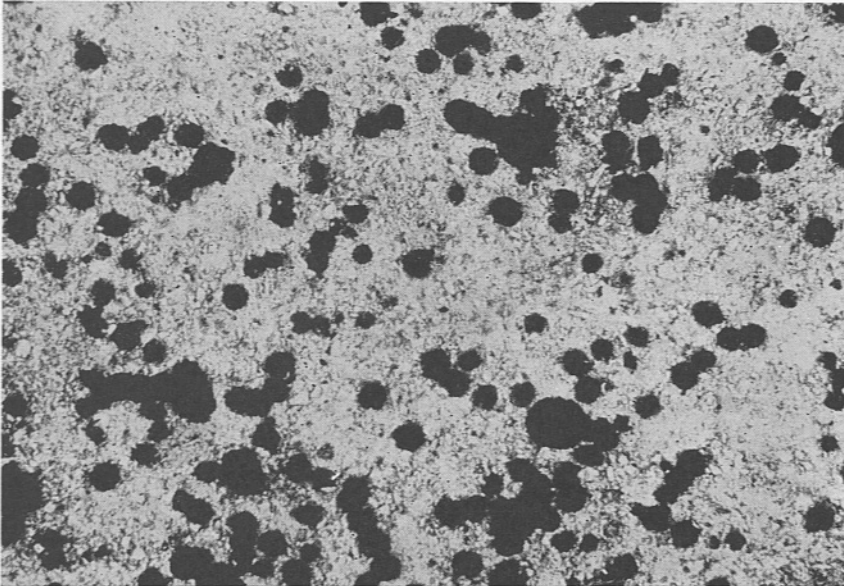


FIG. 2B.—Photomicrograph of thin section from core of Bartlesville sand taken at depth of 631 $\frac{1}{2}$ feet in Sinclair Prairie Oil Co.'s Viola Bumgarner No. 15 well in NE. $\frac{1}{4}$ of Sec. 2, T. 26 N., R. 16 E., Nowata County, Oklahoma. Shows siderite concretions in silt matrix. Magnetite centers can not be distinguished in photograph. (Magnified 25 times; direct light.)

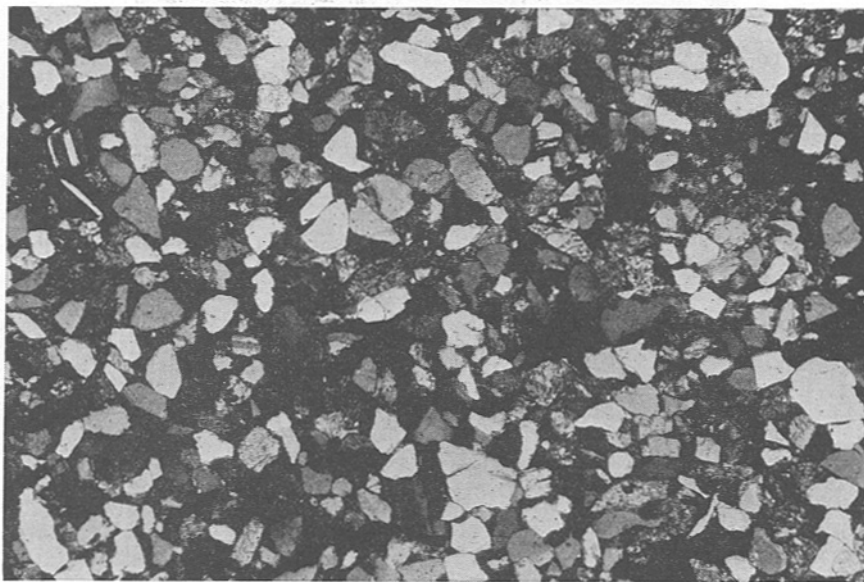


FIG. 3A.—Photomicrograph of thin section made from core of Bartlesville sand taken at depth of 1,536–1,540 feet in W. C. McBride, Inc., well No. 54 in NW $\frac{1}{4}$ of Sec. 17, T. 23 N., R. 12 E., Avant oil field, Osage County, Oklahoma. Most sand grains are of fine and medium sizes, angular and sub-angular shapes. Medium size grain of feldspar occurs about $\frac{3}{4}$ inch below upper left corner of photograph. (Magnified 25 times; crossed nicols.)



FIG. 3B.—Photomicrograph of thin section made from core of Burbank sand taken at depth of 3,065 feet in Phillips Petroleum Co.'s Rhoads No. 6 well, Sec. 9, T. 27 N., R. 5 E., Burbank oil field, Kay County, Oklahoma. Sand is well sorted, mostly of fine and very fine sizes, and angular and sub-angular shapes. Grains of chert and rock particles other than quartz show as speckled grains. Fairly large stippled area near center of upper right quarter of photograph represents ferrous magnesium calcium carbonate cement. (Magnified 25 times; crossed nicols.)

sand. Therefore, the writer refers to the sand bodies in eastern Osage County and Washington and Nowata counties, Oklahoma, as Bartlesville, and the sand bodies in western Osage and Kay counties, Oklahoma, and Cowley, Butler, and Greenwood counties, Kansas, as Burbank.

REGIONAL CHARACTERISTICS OF SANDS

Cores of the Burbank and Bartlesville sands show that they range from massive beds to finely laminated layers. In the finely laminated parts of the cores the quartz, mica, other minerals, and carbonaceous material are segregated into fine laminae that are sharply defined (Fig. 2A). In some cores the iron-magnesium-calcium carbonate is also segregated in fine laminae. In some cores the bedding appears to be horizontal while cross-bedding is shown in others.

Regionally, the Bartlesville and Burbank sands are remarkably uniform in both composition and texture despite the fact that they are characteristically lenticular. The two sands are so similar in composition and physical character that the writer is unable to differentiate them with certainty although certain differences are discernible when comparing sands from two or more specific localities. However, the differences in the Bartlesville sand at two localities in eastern Osage County where no Burbank sand occurs are commonly as great as the differences between the Bartlesville sand from a specific locality in eastern Osage County and the Burbank sand from western Osage County. Furthermore, differences in texture and even in composition of the sand in different parts of a large oil field are as great as differences found between two sand bodies in widely separated localities. Nevertheless, in certain fields the sand is sufficiently distinctive in composition and physical character to distinguish it from the sand in another field in the same general region. For instance, the Bartlesville sand in the Avant field, in eastern Osage County (Fig. 3A), has several features which distinguish it readily from the Burbank sand in the South Burbank or Burbank fields. The sand in the Avant field is coarser-grained, the grains are not so angular, they show a higher percentage of secondary enlargement, and the sand in general is more friable than that in the Burbank (Fig. 3B) or South Burbank fields.

The Burbank sand in the Madison field (Fig. 4B) in Greenwood County, Kansas, is finer-grained, contains a higher percentage of silt and is less well sorted than the Burbank sand in the Rainbow Bend field (Fig. 5B) of western Cowley County. Likewise the Burbank sand in most of the fields in Greenwood County, Kansas, is finer-grained than the Burbank and Bartlesville sands of most of the fields of Osage County, Oklahoma, with the notable exception of the Naval Reserve

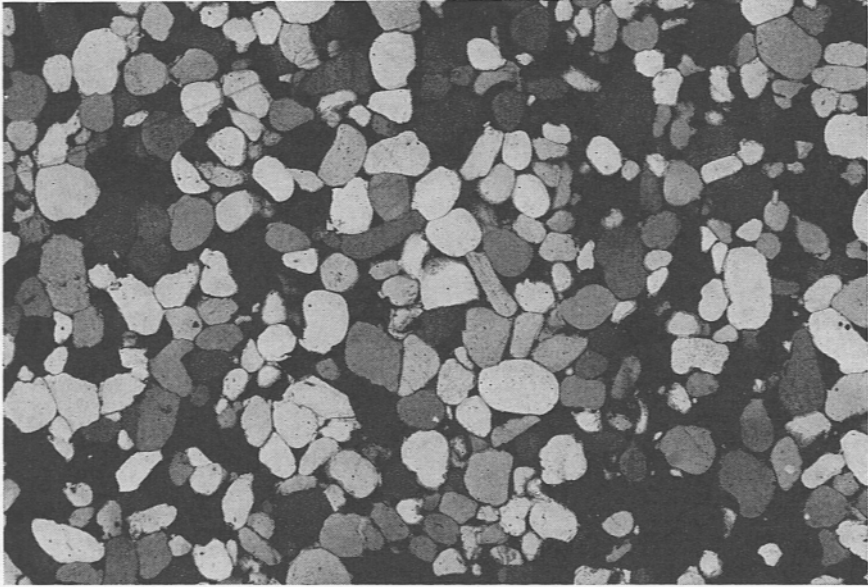


FIG. 4A.—Photomicrograph of thin section made from core of "Second Wilcox" sand from well in Oklahoma City field, Oklahoma, showing mostly medium size, rounded and sub-rounded quartz grains. Almost all sand grains are quartz. (Magnified 25 times; crossed nicols.)

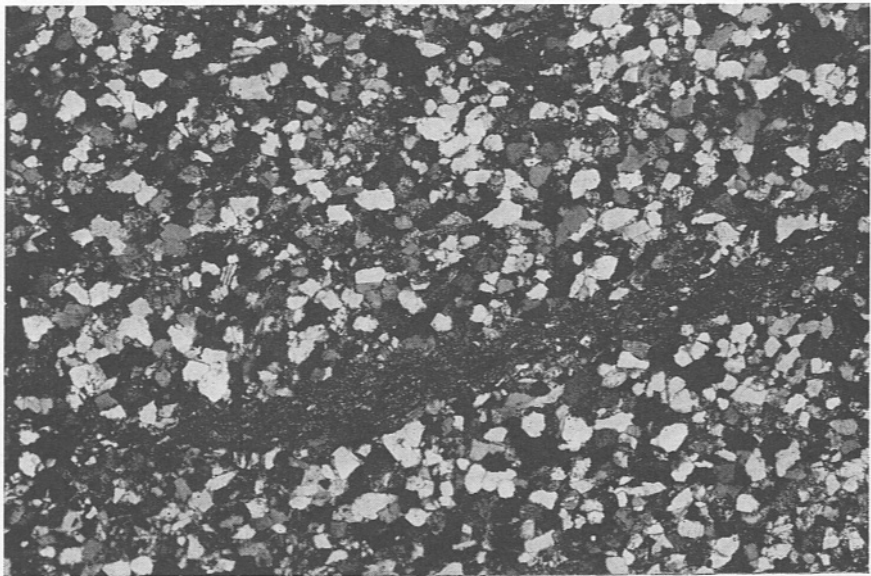


FIG. 4B.—Photomicrograph of thin section from core of Burbank sand taken at depth of 1,846 feet in Empire Oil and Refining Co.'s Kipfer No. 14 well in Sec. 14, T. 22 S., R. 11 E., Madison oil field, Greenwood County, Kansas. Shows predominantly very fine, angular and sub-angular sand grains. Thin bed of black carbonaceous silt crosses lower half of photograph. Striped grain near middle of left half of photograph is grain of feldspar. (Magnified 25 times; crossed nicols.)

oil field where the Burbank sand is as fine-grained as that in any of the Greenwood County fields. The Greenwood County sands have a higher content of silt, clay, and siliceous and carbonate bond, and a higher percentage of secondary enlargement of the quartz grains than the Osage County sands. On the other hand, the Burbank sand of the Quincy field (Fig. 6A) in northeastern Greenwood County is locally composed of coarse, sub-rounded, and rounded grains, and, in fact, grains of this kind are more abundant here than in any other locality examined.

In general, the Bartlesville sand in eastern Osage County has coarser and less angular grains (Fig. 3A) than the typical sand of the Burbank (Fig. 3B) and South Burbank fields in Osage County or than the sands in Cowley County, Kansas (Fig. 5B). Parts of the sand body in the Naval Reserve field are in general unlike any of the other sand bodies in that they consist in the main of very fine-grained sand with which is mixed an abnormally high percentage of silt—as much as 25–30 per cent in the productive part. The examination of samples shows that in general the Bartlesville and Burbank sands outside the oil fields are decidedly finer and more angular, and have a higher silt content than the sands within the fields.

To throw light on the origin of the Bartlesville and Burbank sands, samples from certain outcropping channel sandstones and present-day beach sands were examined. In general, the Missouri channel sandstones (Fig. 6B) are less well sorted than the Bartlesville and Burbank sands from southeastern Kansas and northeastern Oklahoma. The coarser grains are more angular; the sands contain a lower percentage of detrital rock fragments such as schist, shale, and chert.

Samples of sand taken from the wall of a water well in a Pleistocene beach immediately west of Dismal Swamp, Virginia, about 40 feet above the present sea-level, and samples from tidal inlet cut banks in recently formed beaches at Cape Charles and Cape Henry, Virginia, are in general similar in degree of sorting and grain shapes to the Burbank and Bartlesville sands. These beach sands, although generally coarser-grained than the oil sands, are laminated much like the Bartlesville and Burbank sands, and, moreover, the beach sands contain shell fragments, carbonaceous material, carbonized plant fragments, feldspar, and approximately the same content of mica as do the Bartlesville and Burbank sands. Locally, the beach sands have a high content of magnetite which is concentrated in thin laminae. The Bartlesville and Burbank sands contain minute concretions (Fig. 2B) which are composed of siderite with magnetite centers. These concretions, like the magnetite in beach sands, are locally abundant

in certain layers and the writer believes that they were originally magnetite sand grains, similar to the magnetite sand which occurs in present-day beaches, but subsequent to deposition were partially altered to siderite.

Clay balls and rounded chunks of the same material as that which comprises the adjacent marsh muck occur locally in the beach sands. Boulders of shale, most of which are rounded to sub-rounded, were found in the Burbank sand in a core from the Pershing field, in samples from the Kasishke, Kennedy No. 11 well in Sec. 16, T. 24 N., R. 7 E., in the Naval Reserve oil field, and in the so-called Bluejacket sandstone at an outcrop near Columbus in southeastern Kansas.⁷

The results of the examination of samples and cores of the Bartlesville and Burbank sands within and outside the oil producing areas, and the producing and non-producing zones within the oil-bearing sand bodies, show that physical properties of the sand, such as the size, distribution of the grains, and the content of silt and clay, are important factors controlling the yield of petroleum from these sands.

Fossils are very rare in the sand and a careful search was made for the few that were found. Indeterminate shell fragments were found in the sand; and spines, bryozoans, fusulinidae, other foraminifera, ostracods, indeterminate shell fragments, conodonts, and plant material were found in thin limestone beds within the sand, in shale beds within, and immediately above and below the sand. Limestone beds that immediately overlie the Bartlesville and Burbank sands in many localities contain fossils in abundance. These fossils establish the marine origin of the Bartlesville and Burbank sands. The only plant fragments that were identified with certainty were fragments of *Cordaïtes* leaves and stems. Charles B. Read, paleobotanist of the United States Geological Survey, who identified the plant fragments, stated that the *Cordaïtes* genus was probably a land plant which grew adjacent to fresh water swamps, but that there is evidence in the material indicating that these plants were killed by saline waters.

COMPOSITION

The Bartlesville and Burbank sands are composed largely of quartz that is in most localities loosely cemented with a mixture of magnesium, iron, and calcium carbonate. The term magnesium siderite or ferrous magnesium calcium carbonate probably fitly describes the cement in most localities. Locally, the sand is cemented with silica, dolomite, and calcite, and the prevalence of new quartz growth suggests that silica forms at least a part of the cement in many parts

⁷ W. G. Pierce, U. S. Geological Survey, called the writer's attention to the occurrence of the boulders in Kansas.

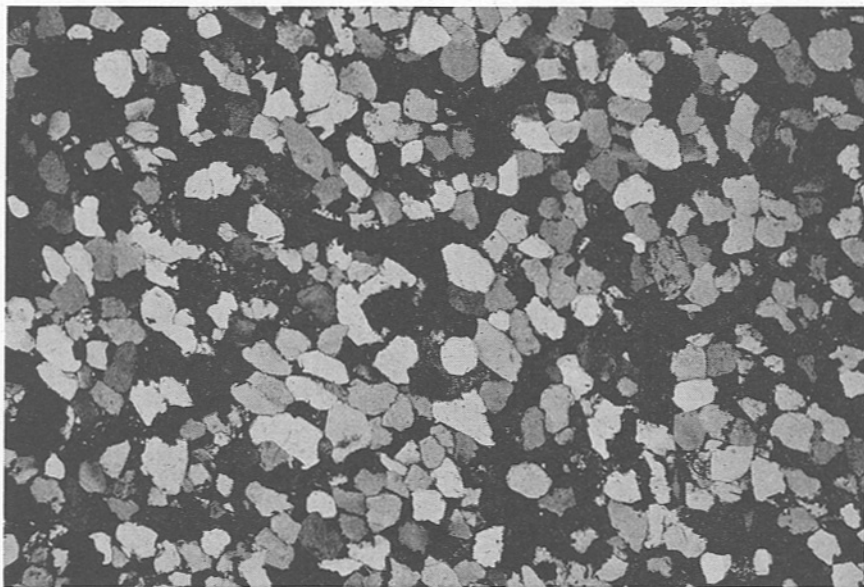


FIG. 5A.—Photomicrograph of thin section of Bluejacket sandstone exposed on Brush Creek, 2 miles southeast of Columbus, Kansas. Sand is composed largely of fine and very fine, angular and sub-angular grains. (Magnified 25 times; crossed nicols.)

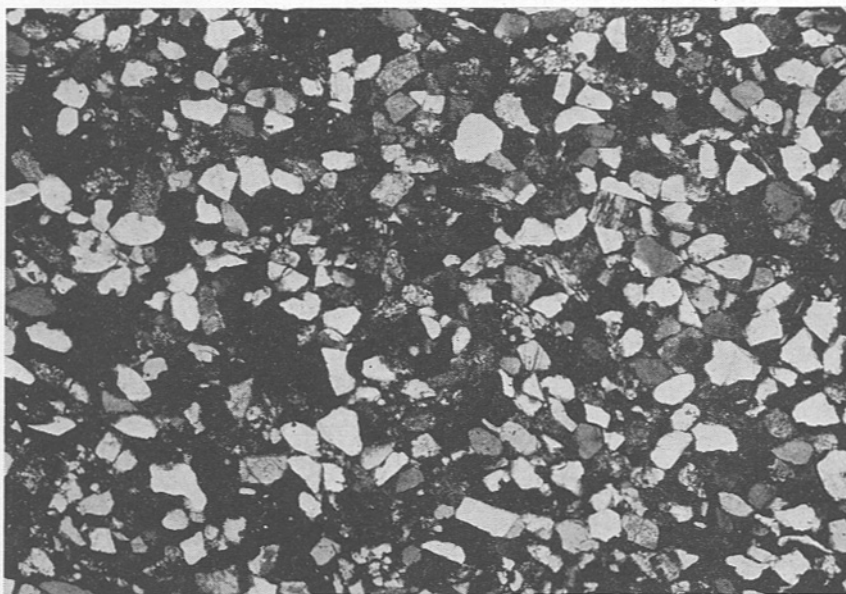


FIG. 5B.—Photomicrograph of thin section from core of Burbank sand taken at depth of 3,268 feet in Barnsdall Oil Co.'s Johnson No. 1 well in SE. $\frac{1}{4}$ Sec. 20, T. 33 S., R. 3 E., Rainbow Bend oil field, Cowley County, Kansas. Most of sand is fine and very fine, angular and sub-angular, and well sorted. (Magnified 25 times; crossed nicols.)

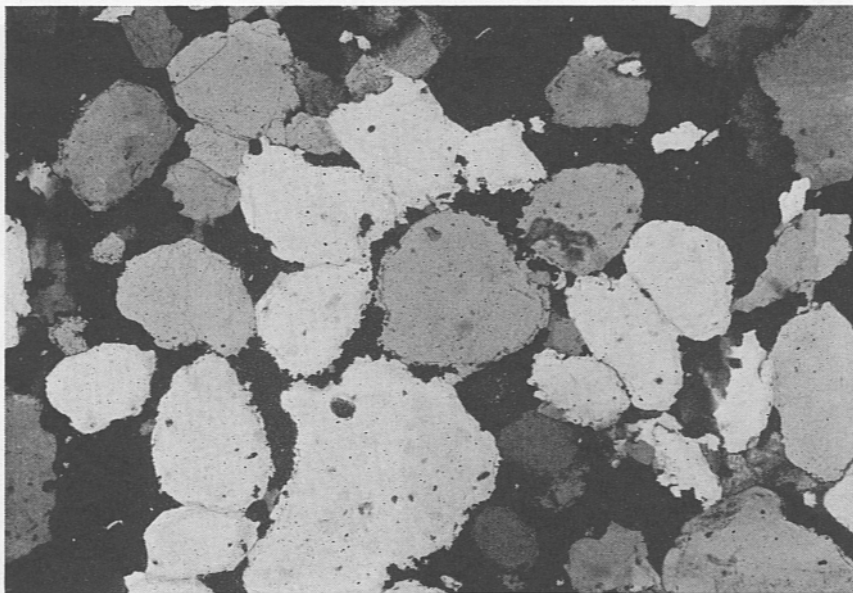


FIG. 6A.—Photomicrograph of thin section from core of Burbank sand from Empire Oil and Refining Co.'s Kolb No. 1 well in Sec. 15, T. 25 S., R. 13 E., Quincy oil field, Greenwood County, Kansas. Rounded and sub-rounded, coarse sand. Irregularly shaped white areas show siliceous cement. Many quartz grains show secondary enlargement which gives margins of grains an irregular outline; dark line inside margin of grain in center of photograph shows inclusions marking boundary of original grain. (Magnified 25 times; crossed nicols.)

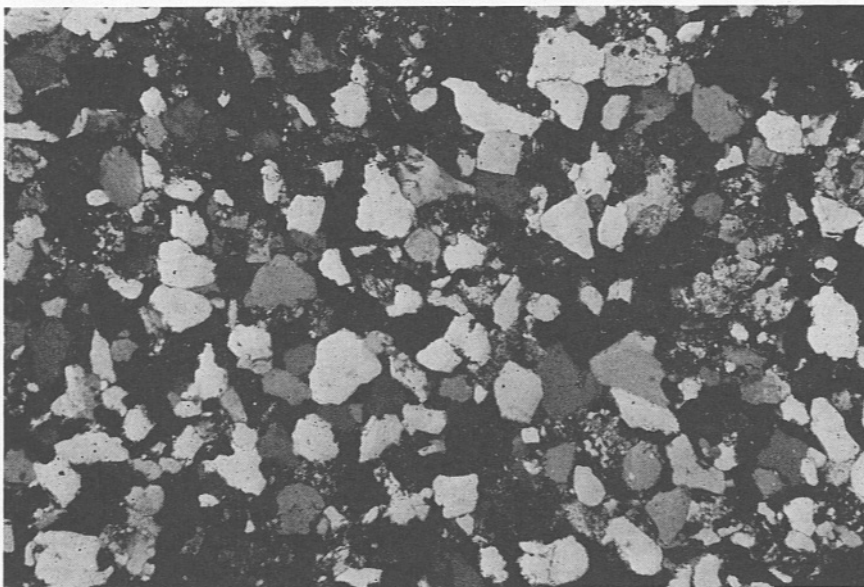


FIG. 6B.—Photomicrograph of thin section of Moberly channel sandstone from Miami quarry, Missouri. Shows poorly sorted angular and sub-angular grains, which range from clay particles to coarse sand. Sand has fairly small content of rock fragments (speckled grains) other than quartz. (Magnified 25 times; crossed nicols.)

of the region. Aside from the quartz the sand contains a small amount, $\frac{1}{2}$ –2 per cent, commonly approximately 1 per cent mica—muscovite and biotite.

Traces of feldspar in very fine grains (Figs. 3A and 4B) are present in all localities from which thin sections of the sand were studied and it appears reasonable to conclude that at least a trace of feldspar is present in the sand everywhere in the region. Traces of minerals, such as zircon, chlorite, glauconite, hornblende, rutile, magnetite, pyrite, and epidote, and 10–20 per cent detrital rock fragments (chert, shale and schist), were seen in the thin sections by the aid of the petrographic microscope, but the ordinary examination of cuttings with the binocular microscope did not reveal them. The abundance of rock particles other than quartz in these sands is one of several features which distinguish them from other oil-bearing sands such as the “Wilcox” sands in the Simpson group of Ordovician age, one of which is shown in Figure 4A. The Bartlesville and Burbank sands everywhere contain a trace to 10 per cent of black shiny grains of carbonaceous material that may be coal or asphalt or merely particles of carbonized plant fragments. Some of the carbonaceous particles seen in cores showed definite plant structure.

PHYSICAL CHARACTERS

The Bartlesville and Burbank sands are almost everywhere predominantly fine-grained; that is, the grains range in size from $\frac{1}{8}$ to $\frac{1}{4}$ millimeter in diameter. In all the writer's size descriptions, except that for the silt and clay particles which she included in one class, she has used the classification of C. K. Wentworth⁸ which is as follows.

	Size in Millimeters
Boulder.....	256 or above
Cobble.....	64–256
Pebble.....	4–64
Granule.....	2–4
Very coarse sand grain.....	1–2
Coarse sand grain.....	$\frac{1}{2}$ –1
Medium sand grain.....	$\frac{1}{4}$ – $\frac{1}{2}$
Fine sand grain.....	$\frac{1}{8}$ – $\frac{1}{4}$
Very fine sand grain.....	$\frac{1}{16}$ – $\frac{1}{8}$
Silt particle.....	$\frac{1}{256}$ – $\frac{1}{16}$
Clay particle.....	Smaller than $\frac{1}{256}$

In many localities three-fourths of the sand grains in the Bartlesville and Burbank sands fall into two classes—fine and very fine (Figs. 3B, 4B, 5A, and 5B)—and these two size classes may be said to characterize these sands. Locally, however, they have a larger content of medium and coarse grains, and even a trace of very coarse grains. For example, the sand of the Avant pool (Fig. 3A) in eastern Osage

⁸ C. K. Wentworth, “Grade and Class Terms for Clastic Sediments,” *Jour. Geol.*, Vol. 30 (1922), pp. 377–92.

County and that of a few other localities in southeastern Osage County is composed predominantly of medium sand grains. Locally, in the main Burbank field the sand contains as much as 30 per cent medium grains. In the vicinity of Nowata in the Chelsea field in Nowata County the sand is considerably finer than that of the Avant field but coarser than that in southeastern Osage County. The Bluejacket sandstone on the outcrop (Fig. 5A), like most of the Bartlesville and Burbank sands, is composed predominantly of fine and very fine grains. In most localities the Bluejacket sand contains approximately 10 per cent silt and clay, but in some localities it is cleaner than this. Much of the sand in the Burbank and South Burbank fields contains only about 5 per cent silt and clay but that in the Naval Reserve field and many of the sand bodies of Greenwood and Butler counties, Kansas, contain 20-40 per cent silt and clay. The content of silt and clay in the Bluejacket sandstone on the outcrop is approximately 10 per cent.

Throughout the entire region the fine, very fine, and most of the medium sand grains are sub-angular to angular. Wherever present the coarse and very coarse sand is sub-rounded to rounded. Approximately 30 per cent of the medium sand is sub-rounded. For instance, the sand grains in the Avant field which contains coarser sand than is found in most localities in Osage County are much more rounded than the sand in other localities. Most of the sand in the Quincy field (Fig. 6A) of Greenwood County, Kansas, which is composed predominantly of medium, coarse, and very coarse grains, is sub-rounded and rounded, and the surfaces of the grains have been etched, giving them the appearance of having a thick, frosted coating. In many of the samples containing coarse sand it is difficult to determine the shapes of the grains from the cuttings because of the prevalence of new quartz growth which produces sharp angles and sharply irregular surfaces. However, in thin sections the outlines of the original grains are plainly visible and are marked by dark lines of inclusions (Fig. 6A).

ACKNOWLEDGMENTS

The writer takes pleasure in acknowledging the cordial coöperation of many Mid-Continent oil companies and individual geologists and operators for supplying core and drill samples and other data; of Luther E. Kennedy, Samuel Weidman, and C. S. Ross for aid in the petrographic study; of George D. Gibson who collaborated with her in the early part of the microscopic study of the oil sands; of N. W. Bass and Hugh D. Miser, under whose direction the work was carried on, for many suggestions; of W. H. Bradley for reading and criticizing the manuscript.